OPTIMIZATION OF GROUND-WATER WITHDRAWALS IN ANNE ARUNDEL COUNTY, MARYLAND, FROM THE UPPER PATAPSCO, LOWER PATAPSCO, AND PATUXENT AQUIFERS PROJECTED THROUGH 2044

by

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KEY RESULTS

Withdrawals from public-supply wells operated by the Anne Arundel County Department of Public Works on average totaled approximately 26 million gallons per day in 2002. Of that amount 2.2, 17.2, and 6.2 million gallons per day were pumped from the Upper Patapsco, Lower Patapsco, and Patuxent aquifers, respectively. The Anne Arundel County Department of Public Works operates five major well fields in those aquifers located in four pressure zones in the central and northern portions of the county. In response to pumping, water levels in Anne Arundel County have declined to as much as 90 feet below sea level. Currently there is adequate available drawdown to sustain the withdrawals. Average-day water demand, however, is projected to increase nearly three-fold to 73 million gallons per day by 2040, with an estimated maximum-day withdrawal of 140 million gallons per day. An increase of that magnitude could cause significant drawdown resulting in water levels falling below the regulatory management level in some areas, well operational problems, increased pumping costs, and reduced stream baseflow. To minimize the regional drawdown effect of the increased demand, withdrawals from Anne Arundel County's public-supply wells were optimized using a numerical, three-dimensional ground-water-flow model (MODFLOW code) constructed for this study in conjunction with an optimization algorithm (MODMAN and SuperLINDO codes) for the period 2005 to 2044. Water demands for Anne Arundel County's well fields were based on the 2003 *Comprehensive Water Strategic Plan* prepared by O'Brien and Gere. The simulation period was extended to 2044 in order to model the effects of the projected 2040 water demand. Additionally, the effects of projected maximum-day withdrawals were evaluated.

Optimized Withdrawals from Anne Arundel County Department of Public Works Supply Wells to Meet Projected 2040 Average-Day Demand of 73 Million Gallons Per Day (pgs. 56 to 69)

The projected average-day demand, optimized to reduce regional drawdown, could be withdrawn without causing water levels to fall below the management level near the well fields. However, the increased withdrawals resulted in relatively deep water levels that increased pumping lift, which would lead to greater energy costs. In addition, the increased withdrawals could eventually result in some reductions in baseflow to streams within the recharge (outcrop) areas of the pumped aquifers.

- Optimized average-day withdrawals increased by approximately 18, 21, and 9 million gallons per day from the Upper Patapsco, Lower Patapsco, and Patuxent aquifers, respectively, by 2040.

- To meet demand, new well fields were modeled at Withernsea, Millersville, and Chesterfield with average-day supply capacities of 3.5, 12, and 8.2 million gallons per day and maximum-day supply capacities of 12, 20, and 15.6 million gallons per day by 2040, respectively. Additional wells would be required at the existing Broad Creek (five wells), Arnold (five wells), Severndale (one well), Dorsey Road (two wells), Crofton Meadows (four wells), and Ft. Meade (two wells) well fields.

- Available drawdown (or the difference between the pumping water level and the management level) in the Upper Patapsco aquifer near the Broad Creek, Withernsea, Arnold, Severndale, and Chesterfield well fields was reduced to 90, 301, 94, 20, and 56 feet, respectively, by 2044. Available drawdown in the Lower Patapsco aquifer near the Broad Creek, Withernsea, Arnold, Severndale, Millersville, Crofton Meadows, and Chesterfield well fields was reduced to 407, 680, 464, 164, 48, 160, and 259 feet, respectively, by 2044. Available drawdown in the Lower Patapsco aquifer at a location central to wells at Harundale, Crain Highway, Glendale, Quarterfield Road, Telegraph Road, and Stevenson Road was reduced to 40 feet by 2044. Available drawdown in the Patuxent aquifer near the Broad Creek, Arnold, Dorsey Road, Millersville, Crofton Meadows, Chesterfield, and Ft. Meade well fields was reduced to 768, 800, 198, 325, 512, 625, and 188 feet, respectively, by 2044. These numbers indicate the relative drawdown "buffer" remaining by 2044 before water levels would reach the management level.

- Simulated model-cell heads, adjusted to represent true heads immediately outside pumping wells, ranged from 29 to 227 feet below sea level in the Upper Patapsco aquifer, 107 to 203 feet below sea level in the Lower Patapsco aquifer, and 97 to 305 feet below sea level in the Patuxent aquifer, by 2044. The lowest water level (205 ft below sea level) occurred in the Dorsey Road well field. Depending on the efficiency of the well, water levels inside the pumping well would be even deeper. Based on the adjusted heads immediately outside pumping wells, pumping lift (or the distance required to pump water to the surface) ranged from 114 to 347 feet in the Upper Patapsco aquifer, 195 to 320 feet in the Lower Patapsco aquifer, and 226 to 373 feet in the Patuxent aquifer, by 2044. The greatest pumping lift occurred in the Dorsey Road well field at 373 feet. Again, depending on the efficiency of the well, pumping lift could be even greater. The greater lift heights would increase pumping costs. Careful well-field design could help to lessen the deep water levels by reducing the drawdown effects caused by well interference and inefficient wells.

- By 2044, simulated baseflow in Sawmill Creek in northern Anne Arundel County, North River in central Anne Arundel County, Northwest Branch of the Anacostia River at Riverdale in northern Prince George's County, and Western Branch at Upper Marlboro in east-central Prince George's County decreased on average approximately 6 percent from the simulated 2002 amounts as a result of the increased withdrawals. In response to a simulated 5-year drought occurring during the period of greatest withdrawals (2040 to 2044) with recharge reduced by 30 percent, simulated baseflow decreased on average approximately 22 percent from the simulated 2002 amounts in the four basins. While not of immediate concern, the reduction of baseflow might eventually affect stream and wetland ecology. Further research would be required to investigate the potential for baseflow reduction and its possible effects on stream ecosystems.

Effects of Projected 2040 Maximum-Day Withdrawals from Anne Arundel County Department of Public Works Supply Wells (pgs. 69 to 71)

While ground-water supply sustainability is more related to the response of the aquifer system to long-term withdrawals, the effects of short-term withdrawals are also important considerations especially as it pertains to well operations. Withdrawals during the day of maximum use—projected to increase to 140 million gallons per day by 2040—might cause significant drawdown resulting in isolated well-operational problems.

- Simulated model-cell heads resulting from maximum-day withdrawals in 2044 were as low as 165 feet below sea level in the Upper Patapsco aquifer at Chesterfield, 177 feet below sea level in the Lower Patapsco aquifer at Arnold, and 203 feet below sea level in the Patuxent aquifer at Dorsey Road.

- When simulated model-cell heads are adjusted to represent true heads immediately outside pumping wells, water levels were as low as 254 feet below sea level in the Upper Patapsco aquifer at Chesterfield, 242 feet below sea level in the Lower Patapsco aquifer at Millersville, and 437 feet below sea level in the Patuxent aquifer at Dorsey Road in 2044. The additional drawdown increased pumping lift to as much as

517 feet (Patuxent aquifer at Dorsey Road). The adjusted water levels fell below well screens in two Patuxent wells at Dorsey Road. To avoid this problem, withdrawals could be redistributed to other wells.